INDUSTRIAL HYGIENE SUPPLEMENT, INDUSTRIAL MEDICINE

This Industrial Hygiene Section is published to promote sound thought upon and concerning industrial hygiene. To that end it will contain articles, discussions, news items, reports, digests, and other presentations, together with editorial comments. The editorial policy is to encourage frank discussion. On this basis contributions are invited.

INDUSTRIAL HYGIENE

The Editorial Committee will exercise its best judgment in selecting for publication the material which presents most exactly the factors affecting industrial health and developments for control of potentially injurious exposures. The editors may not concur in opinions expressed by the authors but will endeavor to assure authenticity of fact.

The Science, the Law and the Economics of Industrial Health

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Industrial Hygiene in Labor-Management Relations

TODAY, more than ever, we are becoming cognizant of the fact that the advancement of industrial hygiene programs depends on cooperative relationships among labor, management, professional groups, and government. Original developments in this field have necessarily depended upon the cooperation of the last three groups. Governmental agencies have carried on laboratory research and field investigations, and have rendered consultation services. Professional organizations have stimulated action and extended the knowledge of their members. Management has employed professional personnel to conduct programs in industry, and has utilized the services of the governmental agencies. Labor has received benefits of a varying quality and quantity from this cooperative effort, but in most instances has had very little to do in the planning and development of these programs. There are several reasons for the minor role played by labor, the main ones being the past lack of organization so that labor could make itself felt, and also the need of adequate knowledge on industrial health programs.

There are many difficulties in the way of effective cooperation which must be recognized before attempting to bring the various groups together. These, however, are not insurmountable, and, in view of the fact that management and labor have so much to gain by cooperative and intelligent application of industrial hygiene methods, one is still curious to know why so much controversy and misunderstanding persist.

We find that conditions are changing. Workers, well organized, are showing increasing concern in the development of policies subscribing to the improvement of their health and welfare. No one can deny the propriety of such interest. Unions are recognizing more and more that their contributions to the well-being of the individual worker must parallel their activities for economic betterment and improved conditions of employment. Many of the signs of labor's interest indicate the possibilities of great achievement through cooperation of all groups. Other signs give rise to concern that wrong steps may be taken by labor because of the lack of forethought and realization of the complexity of industrial health problems. Moreover, there are many indications that more education in the technic of cooperation is needed for all groups, and especially at the plant and local union level. This is particularly true with regard to health and welfare activities which should be of permanent concern to labor and management.

IN REVIEWING recent developments, we find some unions attacking the problem through the medium of the collective bargaining contract. Health and saefty clauses in union contracts are nothing new, since many such provisions have existed for some time. However, most of these clauses cover only one or a few items and consequently have little influence in the establishment of an adequate health and safety program. Recently, one international union has formulated suggested health and safety clauses which are the nearest approach to a comprehensive health program. Obviously, like any first attempt, these proposals will need revision and should be subjected to the test of trial and error. In general, health and safety clauses fall into three categories: (1) Provisions with regard to physical examination of workers; (2) safety and health provisions; and (3) insurance benefits. Only the first two need be touched upon here.

An excellent beginning has been made already with regard to cooperative effort on the controversial problem of employee *physical examinations* (see the report on employee physical examinations by the American Medical Association's Council on Industrial Health (INDUSTRIAL MEDICINE, October, 1944). Thus, management, labor, and industrial hygienists have an authoritative guide to the constructive application of preventive medicine. Let us hope that it will be used.

One important factor which was not covered in the above report is, however, of deep concern to all groups involved. This is the fact that the physical examination is not only a medical problem, but also a socio-economic problem. Perhaps this latter phase did not fall within the scope of the AMA report, but nevertheless it is of considerable concern to management, and especially to the worker who may find that his physical examination reveals the necessity of his

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either giving up his present employment entirely, or changing over to a less arduous but less remunerative job. Possibly this is one of the many problems in health and welfare which can be solved satisfactorily only by national and state legislation to provide adequate economic security for the workers handicapped by accident or disease. Problems of a somewhat similar nature have been solved in this way. We are particularly aware of the usefulness of the second-injury fund in compensation claims. Some arrangement might be employed to take care of older workers and others whose earning capacity has been lowered.

INDUSTRIAL hygienists have a definite responsibility and can play an important role with regard to the second category, namely, *safety and health*. A program of education on industrial hygiene requirements and standards is especially indicated. Industrial hygienists have the means to implement such a program and should consider taking the initiative and leadership in this field. In this regard, industrial hygienists, when developing educational programs for labor, should emphasize the importance of health requirements as an end in themselves, in contrast with the use of health problems as a means to obtain other concessions, such as higher wages and shorter hours. Some progress in education has been made in a few industries where active labor-management subcommittees on safety and health have existed. To date the major emphasis by these committees has been on accident prevention—the one field which has been an established, legally-protected activity over a period of three decades. Industrial hygienists should point out the new opportunities for the improvement of working conditions and workers' health which have as yet not been fully explored.

The major health problems of the working population, however, cannot be solved by union agreements or by management, labor, professional workers, or governmental agencies alone. Undoubtedly, present Federal and state provisions on the subject of health maintenance are inadequate; certainly they are not uniform. The emphasis, therefore, should be more on revising and strengthening our present health and safety requirements, and especially their enforcement provisions, so that the benefits of such standards will be applicable to all workers rather than to those who happen to be powerful enough to obtain concessions through contracts. To this end, industrial hygienists need the support of labor, as well as management, with both getting behind proper legislation which would provide state and local agencies with the necessary funds and trained personnel to do an effective service job. Such action is a far more democratic method of accomplishing the desired objective than through collective bargaining procedures alone, and, in addition, would serve the millions of workers who are still unorganized.

During the early part of the coming year, most of our legislatures will be in session. A number of states are now working on legislation to provide for the establishment of adequate industrial hygiene services. In developing support for such legislation, management and labor should be informed and their support solicited. However, any action taken by labor and management in the health and safety field should be preceded by a careful study of all the factors involved. A first step in developing the required understanding at all levels of union organization would appear to be the appointment of *individuals* to the executive staffs of national and state union organizations, and to each international union staff, with responsibility for full-time attention to health matters. Management has already seen the wisdom of such action, as typified by industrial health committees of the National Association of Manufacturers and the U. S. Chamber of Commerce. Industrial hygienists have an interest and an obligation to work with management and labor, and should help both groups in every way possible to attain their objectives, first being sure that sound objectives are established through full understanding.

Perhaps 1945 may well mark the beginning of an appreciation that labor and management have a contribution to make, and that statesmanlike cooperation can be expected where confidence is established on all sides. —J. J. BLOOMFIELD, President,
AMERICAN INDUSTRIAL HYGIENE ASSOCIATION.

Report on the Quartz Crystal Industry

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AS A RESULT of the tremendous demand of the armed forces for communication equipment, a new industry has grown up in Kansas City, Missouri, that of the manufacture of quartz crystals for radio oscillators. This area has become one of the principal centers of production of this essential item. These are a very important part of every radio transmitter used in ships, planes, tanks and similar equipment, as well as in radar and other electronic devices.

This new industry is very interesting from the standpoint of the intricacy and variety of the operations involved, and has attracted many professional workers who have entered this field, carrying on production work and research, and managing plants. In our contact with this industry we have found nurses, medical students, professors, engineers and similar persons engaged in all phases of the work. The technical nature of the processes, requiring in many cases some understanding of physics, crystallography and chemistry, no doubt accounts for much of its attraction for professional personnel.

Anther interesting characteristic has been the very high degree of cooperation between plants engaged in this work, of which there are at least seven in Kansas City. When new processes and methods of manufacture are developed in one, they quickly spread to the others with the knowledge and good wishes of the developer of the idea. This has resulted in rapid progress in improved methods of manufacture. It has been our experience that the methods of handling and working crystals vary in details in every plant. Much progress has been made and many difficulties overcome during the transformation of a small, highly skilled, almost handicraft type of industry to a mass production basis in an extremely short time.

Method of Manufacture

THE process of manufacturing quartz crystals consists briefly of several generally well defined steps. The crystals, most of which come from Brazil, arrive at the plant and are given certain preliminary observational tests and sorted according to quality.

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They are roughly oriented according to the angle of cut[1] desired and then mounted on plates by means of melted beeswax and rosin and taken to the saw room, where a preliminary slice is made on a portion of the crystal by means of a diamond-edge circular saw. The various crystallographic axes of the crystal or slice are then located by the use of the x-ray, and the crystal is mounted or adjusted under the saw and a second slice made at the required angle to the axes. This second slice is again x-rayed, and final angular adjustments made for complete cutting of the mother crystal.

These slices of the mother crystal, which are known as wafers, are etched with hydrofluoric acid to detect flaws due to twinning of crystals, and are then cut by means of small high-speed, diamond-edge saws to pieces approximately the required size, discarding those portions shown by the etching to be unusable. After this trimming operation the crystals are squared to make all angles right angles, and then are given three or more stages of grinding in machines known as lap-grinding machines, using progressively finer grades of abrasive, usually carborundum powder in some liquid. After the final lap grinding the crystals are ground by hand on a glass plate, using a very fine abrasive, until they are the required thickness. This latter is determined by electronic measurement of the frequency of oscillation of the crystal. Several newer methods of finishing are now being used in certain plants in Kansas City.[2] After final grinding the crystals are cleaned, tested, mounted and put through the various final tests required by the Signal Corps.

Health Hazards

FROM this outline it can be seen that certain health problems can readily arise. The Kansas City Area Industrial Hygiene Service has endeavored to assist the plants in the solution of some of these problems.

Dermatitis—One of the first problems encountered was that of dermatitis for which there are numerous sources. The preliminary optical tests on the mother crystals and various optical tests on the wafers require submersion in some clear liquid, preferably one having a high refractive index approaching that of quartz. White mineral oil or kerosene usually forms the basis of such liquids, with the addition of highly refractive substances. Halowax was used at first in some plants for this purpose but was discarded because of the dermatitis problem. A solution of Dowtherm in decahydronaphthalene was also used. At the present time many of the plants have found it possible to make tests with liquids of lower refractive index, such as the white oil or kerosene alone. Some slight dermatitis is still encountered from this source, due to the defatting action of these materials.

Other sources of dermatitis have been solvents, such as xylol, carbon tetrachloride and methyl alcohol used for cleaning the crystals at various stages. The oil which flows over the crystal during sawing has been a source of typical cutting oil dermatitis. Both soluble and insoluble oils have been used for this purpose. The use of hydrofluoric acid has resulted in troublesome skin burns.

While all of these dermatitis problems have not been solved as yet, much progress has been made. Experience has eliminated many of the more serious sources of dermatitis such as halowax. Some of the plants have devised ingenious devices for handling the crystals to eliminate contact of the worker's hands with the oils and solvents. Protective clothing has been used with success to protect operators of the saws from the oil spray thrown off by these machines. Several plants have a program of regular rotation of workers among various jobs, which tends to reduce the problem somewhat and to enable management to keep susceptible workers out of jobs where they are most exposed to skin hazards. Frequent changes in operations, development of new methods and use of new materials have made the dermatitis problem one requiring continual vigilance. The Industrial Hygiene Service has stressed the primary importance of personal hygiene and has endeavored to raise the sanitary standards in all plants. Educational materials on the subjects have been placed at the disposal of such plants as have desired to use them, and consultation on specific problems has been given.

Hydrofluoric Acid—A second problem of considerable importance has been presented by the use of hydrofluoric acid. This has largely been confined to a small number of workers and it is our recommendation that the etching operation be isolated as completely as possible from other operations. By this means only one or two workers are permitted access to the etching baths, and they can be thoroughly trained in safe methods of handling, use of protective equipment, and appreciation of dangers involved. All of the plants have provided effective exhaust hoods over the baths to prevent the escape of vapors. New commercial etching solutions have been developed and have been adopted in some measure by the majority of the plants, replacing much of the hydrofluoric acid. These etching compounds consist largely of fluoride salts in solutions of weak acids, and, while they are less hazardous than the free acid, adequate ventilation and protective clothing are still necessary.

A later development has been the use of these etching compounds to bring the crystals down to final thickness and so to eliminate the hand grinding to some extent.[2] Under such circumstances, it is difficult to isolate the etching operations, and this problem is now under study.

X-ray—The use of x-ray testing methods has been of some concern to the Industrial Hygiene Service but, so far, there has been no evidence of injury from this source. The x-rays used are of low power, 35,000 volts in most cases, and the machines are equipped with guards which cut off the ray beam when the guard is raised. However, in one case we found the guard had been completely removed, and in another had been altered to keep the beam on when the guard was raised so that large crystals could be tested. Our concern in this problem has been with two dangers: one arising from burns due to exposure to the direct ray beam, and the other, systemic effects from long continued exposure to scattered rays. While the intensity of these x-rays is quite low the exposure times are comparatively long, particularly in the larger plants where one or more machines are in almost continuous operation. We have not had equipment to make quantitative tests of the intensity of scattered radiation but have made certain general recommendations designed to afford some protection. These include periodic blood counts for operators, wearing and development of small dental x-ray films, and rotation of workers on this job. Thus far, the dental films have revealed no evidence of exposure and, while many of the plants are having blood counts made, no abnormal blood pictures have come to our attention as yet. Rotation of workers may be difficult to secure in some cases, since a certain skill must be acquired by the x-ray operator if he is to keep up with the sawing operations. We hope to be able to make the necessary physical tests for radiation intensity, and so establish standards for maximum duration of exposure.

Quartz Dust—In any plant engaged in cutting and grinding quartz crystals it is only natural that the dust problem should be given very serious consideration. The type of material handled, namely, crystalline quartz, constitutes one of the purest forms of quartz employed in any industry and, for this reason, considerable study was devoted to this problem. All cutting and grinding of crystals are done wet. The cutting or sawing is done with diamond-edge circular saws under a continuous stream of either oil or an oil-water emulsion which flows over the saw blade and crystal during the entire cutting operation. Most of the grinding is done using carborundum suspended in a liquid medium.

Several of the operations immediately suggest themselves as possible sources of dust, and these were studied in considerable detail. They include crystal sawing and trimming, horizontal grinding for squaring up the crystals, lap grinding and hand grinding. It was found that dust counts on samples taken in the breathing zones of operators of the saws were generally below a value of 5 million particles per cubic foot, but enough counts above 5 million particles per cubic foot were found to indicate that dust is a potential hazard in this industry. Counts on samples collected around the various grinding operations were generally much lower than around the sawing operation and, of course, the dust from the grinding operation consists of carborundum as well as silica.

It was found that the dust from the sawing operation is of extremely small size. For this reason and because of the high purity of quartz involved, it is felt that the limit of 5 million particles per cubic foot may possibly be too high for this type of dust, and that every effort should be made to keep counts far below this value. In Table I are shown the various dust counts obtained on these operations.

TABLE I.
DUST COUNTS

Operation	No. Samples	Max.	Min.	Average
Crystal cutting saws	28	15.6	0.4	3.1
Trim saws	6	13.0	1.1	4.4
Horizontal grinders	5	7.7	0.8	2.6
Lap grinders	9	2.1	0.5	1.1
Hand grinding	3	0.3	0.2	0.3

It was found that the principal source of the air-borne dust was the fine oil spray thrown off from the cutting oil by the rapidly revolving saws. The cutting oil is recirculated and gradually becomes heavily laden with fine particles of quartz, and the longer the oil is used the greater becomes the concentration of quartz particles in the oil. For this reason, dust counts were made on the oil itself and samples of oil were taken simultaneously with air samples. Dust counts were made on the oil by diluting it with water 20,000 times and counting in Dunn cells. The results of these correlations between oil and air dust counts are shown in the following table.

TABLE II.
DUST COUNTS IN CUTTING OIL AND IN AIR

Date	Dust Counts		No. of days oil used
	Oil	Air	
9-30-43	8.0	13.2	.....
10- 7-43	11.7	3.4, 5.5, 7.5	.....
10-18-43	5.2	2.3, 3.7, 15.6	.....
11-19-43	3.6	1.1, 1.2, 8.6	Oil in use 4½ days
11-23-43	0.9	0.9, 1.7, 1.9	Oil in use ½ day

Dust counts in oil expressed in billions of particles per milliliter.
Dust counts in air expressed in millions of particles per cu. ft.

Except for the first sample in the Table II, all were collected in a single plant. One factor brought out by this study was that, although the higher air-borne dust counts were generally obtained when the oil was most laden with dust, as might be expected, there were a number of individual high results showing that it was sometimes possible to obtain high air-borne dust concentrations when the oil dust concentration was fairly low. This we must attribute to differences in operation, causing the liberation of more oil spray at some times than others. Most of the saws are equipped with guards similar to other circular saws used for cutting wood, and the guards have extensions or skirts made of chamois or some similar soft material. This surrounds the blade and crystal during cutting and reduces the spray considerably. However, through carelessness these guards are frequently badly adjusted or may be impossible to adjust correctly for large or odd-sized crystals. At such times, particularly, large quantities of mist are thrown off.

As a result of this study regular oil changes were recommended as one means of dust control, although it was emphasized that this was not the only need. In order properly to control the quartz dust liberated by the sawing operations, exhaust ventilation is the only certain measure. However, there are certain difficulties in applying this. The cutting saws are rather bulky and it is necessary that they move up and down and be accessible for adjustments of the cutting angles. For this reason, a fairly large area must be ventilated, and hence a considerable volume of air must be exhausted on each saw. There were objections to this measure because most of the plants operate a rather large number of saws and would require a great increase in plant heating capacity during the winter months if all of this air were exhausted. No satisfactory means of removing the oil and dust to permit recirculations has been devised as yet.

Several other recommendations were made to the plants to assist in controlling the dust hazard. These include regular and frequent rotation of workers to less dusty jobs, careful supervision by foremen to reduce the amount of visible oil spray as much as possible, regular oil changes, and the use of respirators in certain cases. The Kansas City Area Industrial Hygiene Service hopes that it will have access to the use of equipment for making chest x-ray pictures in the near future, and it has been recommended that a study be made on these workers. This should be valuable because the exact effect on the lungs of breathing fine oil droplets containing silica dust is not known at present. It has been recommended to all the plants that pre-employment and periodic chest x-rays be made on all workers employed near the sawing operations.

Solvents—Xylol and carbon tetrachloride are used in considerable quantities in the quartz crystal industry. Acetone, methyl alcohol, ethyl alcohol, amyl acetate, and lacquer thinners are used in smaller amounts. Because of their toxicity and their widespread use, considerable study was given to the xylol and carbon tetrachloride exposures. These two solvents are used to wash the mother crystals after submersion in testing oils, for washing the beeswax-rosin cement from the mounting bases and from the wafers after sawing, for cleaning machines and crystals after lap grinding, and for cleaning crystals after hand grinding. In most of the plants a large number of small flat crystals are cemented into a pile or block with beeswax-rosin after the trimming operation and are all ground square at the same time. After squaring, the cement is melted off and the crystals are washed with xylol or carbon tetrachloride. Many of these operations were per-

formed in areas of limited ventilation and, in the autumn of 1943, a number of cases with mild symptoms of poisoning were reported among workers handling these solvents. These cases occurred immediately after the onset of cold weather when the natural ventilation was restricted. Air samples were collected at most points where the solvents were used, and the results of analysis on these samples are shown in Table III.

TABLE III.
SOLVENT CONCENTRATIONS IN CRYSTAL PLANTS

Operations	No. Samples	Maximum Concentrations p.p.m.	
		Xylol	Carbon Tetrachloride
Washing crystals after oil immersion	4	142	...
Washing cement from wafers	1	110	...
Washing cement from cutting bases	9	315	...
Washing crystals after separation of blocks..	14	440	174
Washing crystals after lap grinding	10	110	170
Washing crystals after hand grindings	1	...	112

These air samples were collected in 750 milliliter bottles, and hence are "grab" or spot samples and can not be taken to represent continuous exposure. Most of the operations are intermittent in nature and the workers are not continuously exposed.

Since these investigations were made many of these conditions have been corrected. Several of the plants have completely eliminated the use of carbon tetrachloride. They have found it possible to use ethyl alcohol or even soap and water on some operations, such as cleaning after hand grinding. In several plants a soluble oil or glycerine has been used as the liquid medium for lap grinding and, as a result, the machines and crystals can be cleaned with water. In one plant an exhaust system was built to remove vapors at the point of origin, and in another the offending operation was enclosed and vented to the outside. Several plants have found it possible to control the vapors by providing better general mechanical room ventilation to replace the curtailed natural ventilation, and in two plants operations were moved to new locations to achieve better ventilation.

Methyl alcohol is frequently used for washing the crystals after the final hand grinding but the hazard from this source has been reduced by the use of rubber-stoppered bottles with small brushes mounted in the stopper. The only reported difficulty from methyl alcohol occurred in a small crowded room where crystals were being washed in methyl alcohol and then blown dry with an air blast. Like the dermatitis problem, the prevention of excessive solvent exposure requires continuous watchfulness because of the changing methods of operation.

Burns from dry ice, exposure to plastics and plastic dusts, cuts from the sharp crystal edges, burns from hot beeswax and rosin have been other sources of difficulty in some plants. An excellent degree of cooperation and a willingness to experiment with new methods of operation have brought the majority of these conditions under control.

Summary

AS A RESULT of the war and because of the great increase in the use of electronic devices, the manufacture of quartz crystal oscillators has greatly increased. This industry has presented many problems of interest to the industrial hygienist, including dermatitis from numerous sources; hydrofluoric acid, x-ray exposures, quartz dust and solvent exposures. These problems have been studied by the Kansas City Area Industrial Hygiene Service and recommendations have been made for their control. Work in this industry is still being carried on and is expected to continue for some time because new methods of operation are being constantly introduced.

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Control of Welding Fumes

—U. S. Navy Yard, Boston—

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THE present war has brought welding to its rightful place in industry. Today in shipbuilding, manufacturing and industrial processes, we are welding a majority of the common metals such as steel, monel, nickel, C.R.S., S.T.S., aluminum, aluminum bronze, phospho-bronze, and various other metals and alloys. Following the war, allowing sufficient time, we can expect practically every industrial metal and alloy to be used in electric welding. In fact, the day is not too far away when complete welding specifications will be issued simultaneously with the introduction of most all new alloys and steels.

To the industrial hygienist this means that the welder will be exposed to potential hazards of many toxic metals. We all know that one of the best ways of producing lead poisoning is by the inhalation of lead fumes. The fumes of all toxic metals create the most dangerous health hazards concerning these metals, and where can we find a more ideal and universal operation than welding for the generation of large amounts of fumes?

The proper control of welding fumes today will not only preserve the health of the present welders, decrease absenteeism, and, all in all, increase production, but also will assist us immeasurably in the control of dangerously toxic metals involved in welding operations in the future.

The following discussion is based upon the control of welding fumes in confined spaces aboard ships under construction and repair. It is believed that these conditions are as hazardous as any, and that the methods of control are applicable to any other welding fume conditions.

THE respiratory health hazards associated with electric arc welding consist of the inhalation of fumes and toxic gases.

Although many types of metal fumes encountered in electric welding may not constitute a serious health problem, they do occur in abundance and cause great delays in welding production in confined spaces. In the case of galvanized iron this delay is increased considerably by incapacitating welders as long as 24 to 36 hours. Psychologically it is a very poor policy to allow working areas to have high concentrations of metal fumes in the air. The welders resent it and certainly do not feel in the best of spirit because of these conditions.

A series of experiments were carried out to determine the amounts of these fumes formed during arc welding under varying conditions. In the first of these experiments various sized rods were used at

minimum operating conditions, that is, low voltage and current settings (Table I).

TABLE I.
TOTAL FUMES—VARIOUS SIZE RODS
(Mild Steel)

Rod Size	Wgt. Fume in % Rod Wgt.	Rod Wgt.	Line Voltage	Current Setting
		Black Iron		
1/8"	3.8 (0.95 gm.)	24.8 gm.	65	Low
5/32"	4.3 (1.60 gm.)	37.5 gm.	65	Low
1/4"	4.1 (5.70 gm.)	138 gm.	60	High
		Galvanized		
1/8"	8.0 (2.00 gm.)	24.8 gm.	65	Low
5/32"	9.7 (3.60 gm.)	37.5 gm.	65	Low

These values are average values of numerous tests made. The first column contains the rod sizes; the second, the weight of fume expressed in percent of the weight of the rod. This value times the weight of the rod as contained in the third column gives the actual weight of fume per rod in grams. These values are in parentheses in the second column. The last two columns contain the line voltage and current setting. These voltages are not the arc voltages but merely the voltage setting at the machine prior to welding.

The amount of fumes generated in percent of rod weights is practically constant, about 4% in the case of black iron. However, in the case of larger sized rods such as 1/4-inch the actual weight of these fumes is considerable—5.7 grams. Generally speaking, welding on galvanized metal gives rise to twice as much fumes as welding black iron. When we consider a good welder working at a fair rate, using up 10 rods in 30 minutes or three minutes per rod, he is actually generating fumes at the rate of .5 grams per minute if he is using 5/32-inch rods, or 1.9 grams per minute if using 1/4-inch rods.

In order that we may visualize the actual quantity of this fume produced from arc welding operations, calculations were made to determine how much fume is produced in a large shipbuilding yard in one day. As a basis for these calculations the total weight of welding rods used in one day was obtained. This resulted in 567 lbs. of fume. If the metal being welded was galvanized this would mean 1,280 lbs. of fume in one day. These values are conservative, since actual welding conditions ordinarily require higher amperage settings than those used as a basis for the above calculations.

The remaining experiments on the amount of fumes generated in electric arc welding were carried out with varying line voltages for these same types of rods (Table II). Columns 3, 4, and 5 contain the

TABLE II.
TOTAL FUMES—VARIOUS LINE VOLTAGES
(Mild Steel) Black Iron

Rod Size	Rod Wgt.	Wgt. Fume in % Rod Wgt. 60 V.	65 V.	70 V.	Current Setting
1/8"	24.8 gm.	2.3 (0.60 gm.)	3.8 (0.95 gm.)	7.3 (1.80 gm.)	Low
5/32"	37.5 gm.	2.3 (0.86 gm.)	4.3 (1.60 gm.)	7.5 (2.80 gm.)	Low
1/4"	138 gm.	4.1 (5.60 gm.)		4.9 (6.8 gm.)	High

weight of fume in percent of rod weight for the three line voltages used. From this table we see a marked increase in the amount of fumes generated with increases in line voltage. An increase in line voltage would necessarily also increase the arc amperage, thereby producing more heat and greater volitalization of metal fumes. The 1/8-inch and 5/32-inch rods show a surprising agreement in the amount of fumes in percent of rod weights for each voltage setting. Actual welding conditions as found in shipyards have such extremes in line voltages. Usually the greater the plate thickness being welded, or the greater the penetration necessary for the weld, the higher the voltage and current values used.

The thought might arise that voltage and amperage control should be the first steps to be taken in fume control. The control of welding fumes by lowering the voltage and amperage to minimum operational values could be partially effected theoretically. Actually however, the welder must use whatever voltage or amperage he deems necessary to produce the desired weld. There is nothing for the industrial hygienist to do but to accept the latter fact, and effect his means of control by some other procedure.

Proper control of welding fumes by other methods have been looked into and in some cases tried out. Such include electrostatic precipitation and supersonic waves in the vicinity of the welding arc. However, operational difficulties, unsafe conditions, and impracticability caused these techniques to be set aside for the present.

Thus far the only proper means of control of welding fumes has been ventilation. We may divide this subject into two subdivisions: general ventilation and local ventilation. First, let us discuss general ventilation and reveal its pros and cons.

General Ventilation

FROM the previous data the minimum amount of air needed to dilute the metal fumes to maximum allowable concentrations of 15 milligrams per cubic meter was calculated (see Table III). Column 1 contains the rod sizes and column 2 the type of metal being welded. The basis for the amount of fume per rod is contained in the third column. The percent flocculation is an estimated value. The last column contains the number of cubic feet per minute needed per welder for each type of rod. These figures are based on a welding rate of 10 rods per 30 minutes.

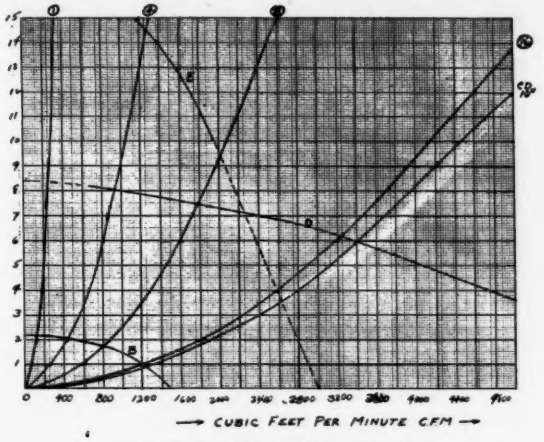
TABLE III.
GENERAL VENTILATION (DILUTION)
Per Welder—(10 Rods per 30 Minutes)

Rod Size	Metal	Bases	% Flocculation	CFM
		Metal Fumes*		
5/32"	Black Iron	4% of Rod	25%	880
1/4"	Black Iron	4% of Rod	35%	2800
5/32"	Galvanized	9.7% of Rod	25%	2140
		Nitrogen Oxides**		
1/4"	Black Iron***	48500 mgm/rod	....	7.6

*Based on 15 Mg/cu. meter.
**Based on 40 ppm NO_2. ***Tebbins and Drinker.

The idea of general ventilation is not too impracticable for one welder in a confined space using 5/32-inch rods on black iron. In this case 880 c.f.m. would do very well in maintaining good general ventilation provided the air is evenly distributed throughout the confined space. However when two or more welders are in a confined space using 1/4-inch rods on black iron or 5/32-inch or 1/4-inch rods on galvanized iron then general ventilation would require over 4000 c.f.m. This volume of air in a confined space of 400 cubic feet, which is not as small as many such spaces encountered in ship construction, would result in 10 air changes per minute. This air movement is altogether too drafty.

Even though general ventilation may be used for the dilution of welding fumes, it is necessary to locate the supply duct or exhaust duct in a position where an even distribution of the air will be maintained throughout the confined space. In the case of supply systems



Graph 1. Fan Characteristics—Three Fans

the duct should end in the farthermost corner from the opening or the air directed into that corner. In exhaust systems for general ventilation the exhaust opening should be located in a position so that the welder is between this exhaust and the opening to the confined space. In order to avoid drafts it is desirable to use the exhaust system, particularly in the winter months when the air has not been pre-heated.

The most serious objection to general ventilation is that the welder oftentimes inhales these metal fumes before they are diluted. General ventilation does prevent the building up of excessive concentrations of fumes and is beneficial in confined spaces where other workers are present with the welders.

In view of these serious objections to general ventilation, it should not be adopted as a sole means of control of welding fumes in confined spaces unless a small amount of welding is being done. Its use is secondary to local ventilation, and it is ordinarily used in conjunction with local ventilation during warm weather when heat and humidity enter into the problem concerning the welders' working environment.

At the beginning of this paper mention was made of metal fumes and toxic gases. I would like to discuss these toxic gases very briefly. Without going into details, I think we all agree that, of these toxic gases, nitrogen oxides are the most important.

Referring to the last line of Table III calculations were made to determine how many cubic feet of air are necessary to dilute these gases to a maximum allowable concentration of 40 parts per million. These calculations were based on Tebbens and Drinker's article.* This value of 48500 micrograms of nitrogen oxides per rod was the highest value they obtained in their work.

From this table we find that only 7.6 c.f.m. per welder is all that is necessary to maintain a concentration below 40 parts per million of nitrogen oxides. It is very evident from this table that our greatest concern with the proper ventilation of welding operations is the metal fumes and not the nitrogen oxides.

Local Ventilation

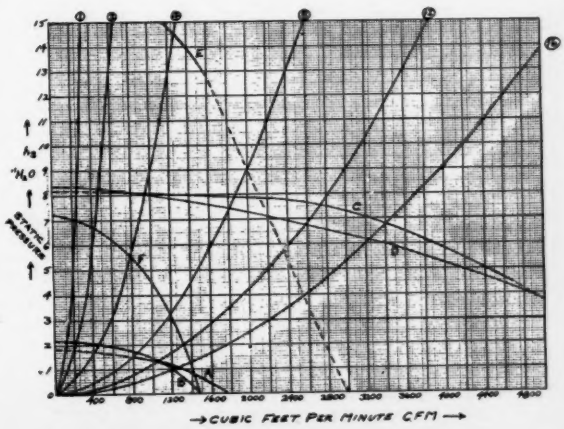
THE most efficient means of ventilation for welding operations is by the use of exhaust ventilation located close to the welding arc. Many of us are familiar with the three-inch and four-inch flexible metal hose 40 to 50 feet in length that is used for this purpose. In order to make this equipment practical for the welder it is necessary to move 200 or more c.f.m. in each of these hoses. Under these conditions all the fumes will be captured up to eight or nine inches away from the opening of the exhaust hose. In order to move this volume of air it is necessary to have the proper type of exhaust fan.

Graph 1 contains the fan characteristics of three types of blowers. These curves tell us what volume of air will be moved by these fans against a resistance of so many inches of water. The curves marked 1, 4, 8, 16 represent the total air movement in 1, 4, 8, 16 lengths of 40 feet of three-inch flexible metal tubing. From curve 1 we see that an air movement of 200 c.f.m. causes a resistance of flow or static pressure of six inches of water. Likewise for eight such lengths the total air movement is 1600 c.f.m., or 200 c.f.m. in each hose causing six inches static pressure. The intersection of the two curves tells us what that particular fan represented by the one curve will move in that number of lengths of flexible metal hose represented by the other curve. Dividing the total air movement by the number of lengths of hose tells us how much air will be moved in each hose.

The lower curve B is a low static fan and will only move 125 c.f.m. in one flexible hose. This is unsatisfactory and should not be used with three-inch hose for exhausting welding fumes. The middle curve D represents a higher static fan and will exhaust 240 c.f.m. using one 40-foot length of three-inch diameter hose. Using 16 such lengths, this fan will exhaust a total of 3200 c.f.m., or 200 c.f.m. in each hose. Obviously this fan can be used for exhausting welding fumes and will take care of 16 welders. The fan represented by the top curve E will move 1300 cu. ft. in four lengths of hose, which means that each hose will move 325 c.f.m. This fan is excellent for use in local exhausts for welders.

The lower curve marked C. D. indicates the resistance to flow caused by various volumes of air through a 10-inch diameter, 50-foot length of canvas duct, used for supply systems in general ventilation. From this graph we see that the fans represented by the lower and middle curves (B and D) are well suited for this use, 1250 c.f.m. being moved in the former, and 3350 c.f.m. in the latter.

In connection with the use of the 40-foot lengths of three-inch diameter flexible metal hose, particularly in ship construction and repair, it is necessary to have an efficient and well staffed ventilation crew. The men in this crew should be sufficient in number to have at least one attached to each ship under construction. They should be instructed and trained in the proper uses of the blowers they handle, and under-



Graph 2. Fan Characteristics of all Yard Blowers

*In J. Indust. Hyg. & Tox., September, 1941.

stand the problems of ventilation for welding operations.

Each man should have in his possession a copy of a graph containing the fan characteristics of all the blowers with which he comes in contact. Such a graph is represented by Graph 2. He should be instructed on how properly to make use of this graph. As a supplement, or in addition to this, he should have a table which indicates what each fan can be used for and what it will do under such conditions of use (Table IV). By having such a ventilation crew, one man for each ship, a keen interest is aroused in each man because he has his own ship to take care of. He can become the welder's best friend.

Recently new types of ventilating units have been introduced into shipyards. One such unit is made by the General Electric Company, Bridgeport, Connecticut, and consists of a motor, fan, filter bag, and complete housing. It weighs 39 pounds and is designed to take care of the needs of any one welder. This unit it is claimed will move 150 to 175 c.f.m. through a 2¼-inch diameter flexible metal hose, 20 feet in length. The principle of this unit involves discharging the air back into the working area after the metal fumes have been filtered out by the filter bag.

Simultaneously, Dr. Silverman, of the Harvard School of Public Health, and myself have been working on a similar unit which makes use of a filter unit arrangement for taking out the fumes captured from the arc. Our unit is designed for use in confined spaces which are difficult to get to, and which may be a considerable distance from a blower. This unit contains a curved baffle, settling chamber and spark arrester in addition to 12, 18-inch filter bags two inches in diameter. A novel feature of this unit is a shaker arrangement for shaking the bags without opening the unit. The fumes fall into a hopper where they accumulate until the cap to the hopper is opened and the fumes poured out.

The baffle and settling chamber collects approximately 25% by weight of the total fume collected. The efficiency of the filter bag is 99.3% on freshly generated iron oxide fume.

This unit is cylindrical in shape; 10 inches in diameter; 34 inches long and weighs 24½ pounds. It is used with an eight-foot length of 1½-inch flexible metal hose, and will exhaust 50 to 60 c.f.m. The motor and fan are made by the Electrolux Corporation, and rated at ½ to 2/3 h.p., 475 watts.

By using 1½-inch flexible metal hose the welder can

TABLE IV.
VENTILATION DATA OF FANS
Proper use of Fans

EXHAUST	A	B	C	D	E	F
1-40 ft. lengths 3 in. (d) flex. hose	105 CFM	117 CFM	240 CFM	240 CFM	335 CFM	215 CFM
	1.7 in. hs	2.1 in. hs	8.2 in. hs	8.2 in. hs	16 in. hs	7.1 in. hs
3-40 ft. lengths 3 in. (d) flex. hose						203 CFM
						6.2 in. hs
4-40 ft. lengths 3 in. (d) flex. hose	100 CFM	113 CFM		235 CFM		192 CFM
	1.6 in. hs	2.0 in. hs		8.0 in. hs		5.6 in. hs
5-40 ft. lengths 3 in. (d) flex. hose					305 CFM	
					13.5 in. hs	
7-40 ft. lengths 3 in. (d) flex. hose			235 CFM			
			8.0 in. hs			
8-40 ft. lengths 3 in. (d) flex. hose					250 CFM	
					9 in. hs	
12-40 ft. lengths 3 in. (d) flex. hose					200 CFM	
					6 in. hs	
17-40 ft. lengths 3 in. (d) flex. hose				200 CFM		
				6 in. hs		
19-40 ft. lengths 3 in. (d) flex. hose			200 CFM			
			6 in. hs			
Recommended for Exhaust	No	No	Yes 4-15 hoses	Yes 4-15 hoses	Yes 5-10 hoses	Yes 1-3 hoses
SUPPLY						
1-50 ft. length 10 in. (d) canvas hs.	1400 CFM	1350 CFM	4550 CFM	4400 CFM	2800 CFM	1420 CFM
	0.6 in. hs	0.5 in. hs	4.8 in. hs	4.5 in. hs	2.0 in. hs	0.55 in. hs
2-50 ft. length 10 in. (d) canvas hs.	800 CFM	720 CFM	2800 CFM	2900 CFM	1500 CFM	720 CFM
	0.2 in. hs	.15 in. hs	1.9 in. hs	2.0 in. hs	0.6 in. hs	0.15 in. hs
4-50 ft. length 10 in. (d) canvas hs.			1475 CFM	1600 CFM		
			0.6 in. hs	0.7 in. hs		
Free air delivery	1725 CFM	1470 CFM	6000 CFM	6500 CFM	3050 CFM	
Recommended for Supply			Yes	Yes	No	No
	Yes	Yes	Lg. CFM	Lg. CFM	Ineffic.	Ineffic.

always handle the end of his exhaust hose with extreme ease and facility, in fact it has been held at the arc in one hand while welding was done with the other hand. The zone of influence of this unit is four or five inches from the end of the exhaust opening.

This unit is not meant to displace the three-inch flexible metal hose exhausting 200 c.f.m. but rather to be used in confined spaces not easily accessible to long lengths of three-inch hose. It is admitted that the small zone of influence of only four to five inches is a decided disadvantage. However, the ease of manipulation of 1½-inch hose plus the portability and independence from any inefficient ventilation crew more or less offsets this disadvantage.

It should be pointed out that the eight- to nine-inch zone of influence of 200 c.f.m. does not meet the welder's requirements completely by any means. The ideal exhaust tube should capture all the fumes while welding one complete rod without moving the tube. This would enable the welder to weld without breaking his arc to move the tube.

Calculations were made to determine the lengths of welds produced from various size rods. These were made with the assistance of a General Electric Welderule which gives the number of feet of weld per 100 lbs. of metal for each type of rod and weld. These calculations revealed lengths of welds per rod of 3.4 to 13.8 inches for ⅛-inch rods, 3.3 to 20.7 inches for 5/32-inch rods, and 0.9 to 26.4 inches for ¼-inch rods. All that can be said regarding the zone of influence, therefore, is that the greater the zone of influence the less the number of times the hose has to be moved. It seems very unlikely that any air movement is ever going to be reached such that a zone of influence of 20-odd inches will be obtained from the end of any type of flexible metal hose. In this case over 1100 c.f.m. would be needed. However, decided improvements can be made in these small portable units by approaching the desired air movement of 200 c.f.m.

These two new types of units were mentioned to indicate the trend in the control of welding fumes. As mentioned previously, our first and greatest concern in welding operation is the fumes given off from the arc. As a consequence the most economical means of getting rid of these fumes is as near to the source of the fumes as possible. A short hose, a filter and fan, and the fumes are collected and prevented from geting into the air.

The use of such a unit gives the welder his own personal means of protection against fumes. He does not have to wait for the ventilation crew to get him a 40-ft. length of flexible metal hose and a fan located nearby. Many times I have seen a welder request ventilation before going down into a confined space to weld. He would get tired of waiting, go down into the space and weld for awhile and finally come up for air for another waiting spell. Sometimes he would have the job finished before the ventilation arrived. This situation describes the greatest problem in the control of welding fumes in shipyards.

A welder has his own helmet, gloves, goggles, sleeves, leggings, welding jacket and welding holder. He takes these things with him wherever he goes. He should also have his own ventilation and take it with him wherever he goes.

I have heard the opinion expressed that a welder should be taught the proper use of a sucker hose. It should be made part of his course when learning to weld. This I agree with 100% but let me add that I can think of no better way of arriving at this end than by supplying each welder with his own unit. Give him this opportunity and he will use his unit as expertly as he does his electrode.

Industrial Health Hazards and Their Control

—In a Bomb Loading Plant—

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FOR the past three years the Industrial Hygiene Division of the U. S. Public Health Service, in cooperation with the Office of the Chief of Ordnance and the Office of the Surgeon General of the Army, has been making industrial hygiene surveys in Army Ordnance establishments. The purpose of these surveys is to appraise the health hazards and advise the management of these establishments of methods for controlling the atmospheric contaminants which are considered harmful to the workers' health.

It will be of interest to compare the figures for fatalities from TNT poisoning during this war and the last war. During the first 93,000 man-years of operations in the present shell and bomb loading plants, there were only eight deaths and 241 cases of TNT intoxication sufficiently serious to cause lost time.[1] However, during the last war, according to the International Labor Office in "Occupation and Health," there were 475 deaths out of 17,000 cases of TNT poisoning in 7½ months of operation.

Most munition plants were just beginning to operate when World War I ended. During the present emergency practically all of the plants have been operating for two years or longer and, as a result, most of the present workers have been exposed to various toxic materials for a considerable length of time. It is to be regretted that we do not have complete figures on illnesses and fatalities of workers in the munition plants of World War I, but, from the figures cited above, it can be deduced that great progress has been made in protecting the health of these essential workers. Much credit should be given to the medical departments in detecting early symptoms, but equally important have been the engineering studies of the working environment. If all hazardous exposures were adequately controlled, there would, of course, be very few workers showing signs of poisoning from toxic materials. There have been unavoidable delays in getting "all around" approval for the installation of local exhaust ventilation systems and other measures for controlling atmospheric dust, vapor and fume. However, we have now reached the point where practically all plants are installing some method of control of the atmospheric contaminants, especially at those operations where the exposures are most serious.

Ordinarily, one not acquainted with bomb loading plants would think only of the health hazard from trinitrotoluene, otherwise known as TNT, which is the principal explosive used in bombs. However, this toxic material is only one of many which are encountered in plants of this type. The health hazards which are most commonly encountered, and the methods advocated for their control, will be described.

Presented at the Annual Meeting of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION, St. Louis, Missouri, May 10-11, 1944.

1. FLINN, ROBERT H.: Results of an Active Health Program in Munition Industries. Proceedings of Eighth Annual Meeting of the Industrial Hygiene Foundation of America, p. 23-25, November 10-11, 1943.

The maximum allowable concentrations have been established for most of the toxic materials encountered in bomb loading plants. It is to be noted that although the atmospheric concentrations are kept below these values, there may be a few workers of low resistance who will become ill from exposures to these substances. However, by keeping the atmospheric concentration below the maximum allowable limit, a large majority of normal individuals will not show any harmful effects.

Most of the operations which are discussed in the following sections are in the same order as the materials flow through the plant. In a few instances this sequence has not been maintained as it seemed more coherent to discuss several allied operations together. A few operations in munition plants which are not performed in bomb loading plants are also described, since serious health hazards have been found associated with these activities.

Spray Painting

THE potential health hazards associated with the spray painting of bombs are the paint pigments and solvent vapors. The constituents of the paints have been found to vary considerably. Two of the most toxic ingredients found in the paint pigments are lead and antimony, while the solvents may contain toxic materials such as toluene.

The spray paint booths are generally provided with a water curtain and mechanically exhaust ventilated. Air velocity measurements taken at the face of these booths ranged from 50 fpm to over 300 fpm. Atmospheric samples collected in the worker's breathing zone have revealed that a velocity of 200 fpm for small spray paint booths (those having a face area of less than 50 square feet), and 150 fpm for large spray paint booths, are needed to keep the concentrations in the worker's breathing zone below the maximum permissible limit. Of course, if the spray gun is manually operated, the object being painted should be between the worker and the exhaust outlet of the booth. If toxic materials such as lead or toluene are used, it is always recommended that a relatively less toxic material be substituted if possible.

Maintenance has been found to be a very important item in insuring an adequate face velocity at the booths. In one plant the same booth was found to have its face velocity decreased 50% in a period of one year. Upon investigation it was discovered that the fan blades and ducts had not been cleaned. As soon as this situation was called to the attention of the management, an adequate maintenance program was put in effect and the fan and ducts were to be cleaned at prescribed intervals. Mechanical installations require care if they are to be kept in proper working order and a spray paint booth is no exception to the rule.

In some instances hot-air driers are used for drying the painted bombs. These driers should be mechanically exhaust ventilated to the outside. On initial visits to several new plants it was found that the exhaust fans were incorrectly installed so that instead of exhausting the hot air from the driers, the outside air was blown through the driers into the work room, causing a potential health hazard. Although it is difficult to believe that new installations of modern design could be operating in this manner, such instances have made us skeptical of the effectiveness of many operations until they have been thoroughly investigated.

Bomb Loading

ALTHOUGH several types of explosives are used in bomb loading, this section will be devoted to TNT, which is most commonly used and the most toxic. The TNT is first screened to remove any foreign materials and also any large lumps which might be present. The usual screen is enclosed and mechanically operated. Atmospheric samples collected at the unventilated feed hopper of the screen showed TNT values ranging from three to 30 times the maximum allowable concentration. To control these high atmospheric concentrations adequately, the hopper should be partially enclosed with one side open to permit filling, and the enclosure should be exhaust ventilated. The face velocity at the hood opening should be a minimum of 300 fpm. It would be well to mention here that at the beginning of these arsenal surveys, face velocities of 150 to 200 fpm were considered adequate. However, experience has shown that these velocities were too low to control the dust generated so that it was necessary to increase the rate of air removal.

Several different discharge systems have been used at the end of the screen, none of which employed mechanical exhaust ventilation. Some screens had nothing more than a canvas sleeve attached to the discharge opening, while others had elaborate enclosed hoppers. Atmospheric samples for TNT collected at these locations showed values ranging from five to 50 times the maximum allowable concentration. The atmospheric contamination with any of these arrangements was not adequately controlled without the use of mechanical exhaust ventilation. The recommended method of control is to install a canopy type hood over the container to be filled. This hood should be of sufficient size to extend about two inches beyond the top edges of the container and should allow one or two inches clearance above it. The discharge sleeve from the screen may extend through the hood and into the receptacle. Such an arrangement requires air removal rate of about 250 cubic feet of air per minute (cfm) through the hood to prevent dispersion of TNT dust into the atmosphere.

The screened TNT is melted in units consisting of steam heated grids totally enclosed by a hood which has four doors, two on either side used for loading the melt unit. Usually, the unit is vented by a stack extending through the roof of the building. Atmospheric samples collected at this location during the filling of the melter showed TNT concentrations ranging from one to three times the maximum allowable concentration. To control the TNT fumes and dust adequately mechanical exhaust ventilation should be provided at the melt unit. The air movement should be sufficient to provide an inward air velocity of at least 150 fpm at the face of the door or lid opening.

After the TNT is melted, it is drawn off into a kettle for preliminary cooling. These kettles should be provided with sufficient exhaust ventilation to maintain an inward air velocity of 150 fpm at all openings. From this kettle the TNT is filled directly into large bombs, while for small bombs the TNT is first drawn off into cooling tubs. The large bombs are partially filled and then they are stirred or puddled, during which time solid TNT is added. Generally, there are a large number of bombs in a bay where the puddling occurs, so that local exhaust ventilation is not practical. General room ventilation with an air change every two minutes is advocated for this operation.

The cooling tubs used to fill small bombs are continually stirred by hand, or, in some cases, mechani-

cally until the desired temperature is reached. Then the TNT is poured into buckets from which the bombs are filled. Funnels are placed in the ends of the bombs to facilitate pouring. After the poured TNT has hardened, the funnels are removed and the solidified TNT knocked out of the funnels. The latter operation creates and disperses a considerable amount of dust into the air. Atmospheric samples collected during the cooling and pouring operations showed TNT concentrations ranging from a trace to two times the maximum allowable concentration. When the doors and windows were closed, the atmospheric TNT concentrations were invariably excessive. General room ventilation similar to that recommended for pouring large bombs is advocated for this operation.

It is necessary to clean the sides and bottoms of the cooling tubs after they are used for several batches of TNT. Usually this operation is performed by hammering the sides and bottom of the tub with a wooden mallet. Excessive dust (from one to eight times the maximum allowable concentration) was created during this cleaning process. It is recommended that rubber liners be used inside the tubs. These liners can be crumpled, thus loosening the encrusted TNT. This operation should be performed in a well ventilated room as a small amount of dust will still be produced.

After the explosive has hardened in the body of the bomb, a tail pour is made. A form is generally inserted in the tail around which the TNT is poured so that a space will remain in which the fuse assembly may be inserted. During this operation the atmospheric concentrations are generally found to be two or three times the maximum allowable concentration. The same recommendation applies here as was given in the pouring and puddling operation.

In all of the operations where local exhaust ventilation is advocated, it is necessary to install a dust collector. This collector should be preferably of the wet type and should be located as near as possible to each hood or booth so as to prevent the accumulation of explosive materials in the ducts and exhausters. Furthermore, these exhaust systems should contain positive type exhausters such as centrifugal fans, and the ducts should be so constructed as to permit routine cleaning operations.

Fuse Loading

THE principal toxic substances encountered in loading fuses are tetryl, mercury fulminate, and lead azide. These substances are liberated into the air as dusts at the various operations.

TETRYL—Tetryl is screened directly into blenders in which the various substances to be blended are thoroughly mixed. The tetryl screen may be a separate unit which is enclosed and mechanically operated, or it may form a part of the hopper used to charge the blender. Large amounts of tetryl dust are liberated when the tetryl is emptied from the shipping container into the screen hopper. The tetryl dust concentration at this operation has been found to range from two to 60 times the maximum allowable concentration for tetryl. An important factor in the amount of dust created is the care taken in performing the operation. The exposure is generally intermittent and of brief duration. An enclosure, provided with a door, should be placed over the screen hopper. A pivoted frame for holding the tetryl container should be built in the enclosure. With the door closed the frame can then be inverted by means of a crank attached to a shaft on the frame and extending through the enclosure, thus emptying the tetryl from the container into the screen hopper.

In emptying the blender, a flexible cloth sleeve is used to conduct the material from the blender to the storage containers. Atmospheric samples taken while emptying the blenders show tetryl dust concentrations ranging from one-half to 25 times the maximum allowable concentration. The operation is intermittent and of brief duration. The high dust concentrations have been found where short discharge sleeves were used and where there was little care in performing the operation. The sleeve extending from the blender should be of sufficient length to reach the bottom of the containers, and the bottom end of the sleeve should always contact the tetryl in the container. The workers should wear U. S. Bureau of Mines approved mechanical filter respirators while emptying the blenders.

In consolidating the blended tetryl into pellets, a small amount of dust is created when the hoppers of the pelleting presses are filled and when the presses are cleaned with small brushes. These operations are intermittent and require only a few minutes to perform. The presses are located in separate rooms and the operators are not allowed in these rooms while the presses are running. Continuous atmospheric samples taken while the operators are performing the various jobs show tetryl concentrations below the maximum allowable concentration.

The tetryl pellets are placed in booster cups which form a part of the fuses. A considerable amount of tetryl dust is dispersed into the air when the pellets are inserted into the cups, resulting from the displacement of the air within the cup by the tetryl pellet Atmospheric concentrations of tetryl dust at this location range from an insignificant amount to five times the maximum allowable concentration, the amount of dust depending to a great extent on the size of the pellets. Down-draft mechanical ventilation through grilles located in the table tops is recommended at this operation. The ventilation rate should be sufficient to provide a minimum air removal velocity of 100 fpm at the source of the dust. The exhaust system should include a suitable wet collector located as close to the exhaust grilles as possible to prevent conveying the dust laden air through ducts.

The auxiliary booster loading is similar to the booster cup loading, the main difference being that several tetryl pellets are placed in an auxiliary booster. The tetryl dust concentration at this operation ranges from five to 10 times the maximum allowable limit. The control measures recommended at the booster cup loading operation also apply to loading auxiliary boosters.

LEAD AZIDE—Lead azide is screened in barricaded rooms, and, since the workers are not in these rooms during screening, the exposure to lead azide is intermittent and of brief duration. Atmospheric samples taken while the workers perform the various jobs in the screening rooms show lead azide concentrations, in terms of lead, ranging from 1½ to 35 times the maximum allowable concentration. The workers should wear U. S. Bureau of Mines approved toxic dust respirators while in the screening rooms.

The loading of percussion elements with lead azide is done manually. At one operation, the form is disassembled and the loose lead azide is brushed from the form and the percussion element. Atmospheric concentration of lead azide, in terms of lead, at this operation range from a trace to seven times the maximum allowable concentration, the amount of dust

depending to a large extent on the care taken in performing the operation. A small vacuum hose is recommended for removing the loose lead azide from the forms and the percussion elements. Two dust traps, in series, filled with a desensitizing fluid and placed a short distance from the end of the suction hose should be used to prevent lead azide dust from getting into the main vacuum line.

MERCURY FULMINATE—Percussion elements are loaded with mercury fulminate in a manner similar to that described for lead azide. The same precautions should be taken as mentioned under lead azide.

Detonators are tested in a small mechanically ventilated booth. A minimum air removal velocity of 200 fpm should be maintained at the faces of the booths.

Laboratories

THE laboratories in manufacturing plants handle much more mercury than those in loading plants, and the health hazards from mercury are sufficiently great to justify discussion in this paper. The greatest mercury vapor hazard occurs in the vicinities of the nitrometers and mercury stills. The necessary precautions in handling mercury are seldom observed. The nitrometers are usually placed along one side of a room which has either a rough wood or a porous concrete floor. The mercury vapor concentrations at these locations were not significant during the first few months of operation. Inspections after the laboratories had been in operation for several months revealed a significant amount of mercury on the floors where the nitrometers and mercury stills were located.

In some laboratories the general room mercury vapor concentrations, with the doors and windows closed, ranged from 0.10 to 0.16 milligrams per cubic meter of air (mg/m^3). In the immediate vicinity of the nitrometers, the concentration ranged from 0.15 to 0.85 mg/m^3 and, at floor level, from 0.22 to 1.9 mg/m^3. In one instance, the general room concentration of the offices and hallways adjacent to the nitrometer and mercury still rooms averaged 0.16 mg/m^3. The floors of these areas were found to be grossly contaminated with mercury. It is likely that the mercury had been tracked in from the nitrometer and mercury still locations. The necessity of maintaining excellent housekeeping at these locations is stressed. The methods for controlling mercury vapors as outlind by the National Bureau of Standards (Research Paper No. 1383) are recommended. The excess mercury should be cleaned from the floors. The floors should then be treated with sulfur, oiled, and a sealed linoleum floor installed. Where the nitrometers are in constant use, mechanical general room ventilation, providing 10 to 15 air changes per hour, is recommended. Chemical analyses from which toxic vapors and gases may be liberated are, in general, conducted in the laboratory hoods. A minimum air removal velocity of 100 fpm should be maintained at the faces of the opened hoods.

Maintenance

GARAGE—High concentrations of carbon monoxide are found in closed garages during times when motors are running and where provision has not been made to remove the exhaust gases from the buildings. Carbon monoxide concentrations of 1,500 parts per million parts of air by volume (ppm) have been found in the vicinity of running motors. During cold weather when the garage doors and windows are closed, flexible tubing should be used to discharge the exhaust gases from running motors to the outside of the building.

Spray painting of automotive equipment is usually done at one end of the garage. The location is not always isolated from the main garage area. Where the spray painting is done in a separate room, a wall fan is generally used to keep the thinner vapor concentration below the lower explosive limit. The jobs are intermittent but each may require several hours. Where lead pigments are used, atmospheric concentrations in terms of lead ranging from 2.0 to 14.0 mg/m^3 have been found, the concentrations depending to a large extent on the amount of lead pigment in the paint. Petroleum distillates and acetates are usually used as paint thinners. However, thinners containing benzene, toluene, and xylene are sometimes used. The spray painting location should be enclosed and exhaust ventilated. Other workers should not be allowed in this room during painting. The operator should wear a U. S. Bureau of Mines approved supplied air (air-line) respirator while spray painting.

DIESEL REPAIR SHOP—When Diesel locomotive engines are run in closed shops, excessive concentrations of the exhaust gases build up in the room. Stacks should be installed in the roofs of the buildings above the exhausts of the locomotives. The stacks should have adapters which may be lowered to fit tightly over the Diesel exhausts.

In some plants, carbon tetrachloride is used to clean the electrical parts underneath the Diesel locomotives. The carbon tetrachloride is applied with either a paint brush or a spray paint gun. It is recommended that the carbon tetrachloride be replaced by a petroleum solvent such as Varsol or Stanisol. These petroleum solvents have been used successfully for this purpose.

INSTRUMENT SHOP—A considerable amount of mercury is used in the instrument shop to repair gauges. In plants where this hazard has not been recognized, a general room mercury vapor concentration of 0.2 mg/m^3 has been found. The source of contamination is spilled mercury impregnated into the table tops and floors. The same recommendations given for the control of the mercury hazard in the laboratory also apply at this location.

ELECTRIC SHOP—Carbon tetrachloride is used to clean electrical parts. There is a reluctance to substitute a less toxic solvent, such as petroleum solvent, the claim being made that other solvents do not give satisfactory results. It is recommended that the cleaning of electrical parts with carbon tetrachloride be done in a mechanically exhaust ventilated booth similar to a spray paint booth having a minimum face velocity of 200 fpm.

LEAD BURNING—Atmospheric samples taken in the worker's breathing zone during lead burning have shown lead concentrations ranging from an insignificant amount to 0.88 mg/m^3. The higher concentrations are found where the burning is done in confined areas. When lead burning is of a short duration and is done in an enclosed space, the workers should wear U. S. Bureau of Mines approved fume respirators. The lead hazard at the burning sites may be controlled by means of good general room ventilation if the sites are not enclosed and if the jobs are intermittent and of brief duration. Local mechanical exhaust ventilation should be provided at all burning sites where the work is of a continuous nature. This can be accomplished by means of a three to four inch diameter flexible metal tube (provided with a source of mechanical exhaust ventilation). The tube should be counterweighted so that it is maneuverable around the work. The tube inlet should be located as close to the work as practicable, and a minimum of 250 cfm should be removed from each burning site. Excellent housekeeping should be practiced to keep lead dust from accumulating on the floor. Dry sweeping of the floor should not be al-

What happens when your hat comes down?

SOMEDAY, a group of grim-faced men will walk stiffly into a room, sit down at a table, sign a piece of paper—and the War will be over.

That'll be quite a day. It doesn't take much imagination to picture the way the hats will be tossed into the air all over America on *that* day.

But what about the day after?

What happens when the tumult and the shouting have died, and all of us turn back to the job of actually making this country the wonderful place we've dreamed it would be?

What happens to *you* "after the War?"

No man knows just what's going to happen then. But we know one thing that must *not* happen:

We must *not* have a postwar America fumbling to restore an out-of-gear economy, staggering under a burden of idle factories and idle men, wracked with internal dissension and stricken with poverty and want.

We must *not* have breadlines and vacant farms and jobless, tired men in Army overcoats tramping city streets.

That is why we must buy War Bonds—now.

For every time you buy a Bond, you not only help finance the War. You help to build up a vast reserve of postwar buying power. Buying power that can mean millions of postwar jobs making billions of dollars' worth of postwar goods and a healthy, prosperous, strong America in which there'll be a richer, happier living for every one of us.

To protect your Country, your family, and your job *after* the War—*buy War Bonds now!*

Let's all KEEP BACKING THE ATTACK!

lowed. The floor should be vacuum cleaned, or sufficient sweeping compound should be used to prevent dispersing lead dust into the air.

Scrap lead may be melted and cast into ingots. The melting site is usually located in a corner of the lead burning shop or in a small shed separated from other buildings. When the melting is done in confined areas and provision has not been made to remove the lead fume from the air, atmospheric lead concentrations have been found to range from 0.2 to 5.4 mg/m^3. The melt pot should be partially enclosed by a hood with a vertical stack from the hood extending through the roof. Natural draft ventilation is adequate if the work is intermittent and of short duration. If the melting operation is fairly continuous, the hood should be mechanically exhaust ventilated. A minimum air removal velocity of 100 fpm should be provided at the hood openings. The dross should be removed carefully from the melted lead and deposited in a suitable receptacle provided with a tight-fitting cover.

WELDING—A variety of operations such as brazing and welding of aluminum, stainless steel, galvanized iron, and mild steel may be done at the same site. If the welding operation is intermittent and of short duration, adequate protection may be given through good mechanical general room ventilation. Local mechanical exhaust ventilation should be provided at permanent welding sites where lead or other toxic fumes are produced. A system similar to that described for lead burning should be used.

Conclusion

THE operations discussed in the foregoing sections are not all of the hazards which exist in a loading plant, but they are the principal ones encountered. It should be pointed out that the exposures for similar operations in different plants and even within the same plant vary considerably. This variation may be due to a slightly different method of procedure, the care with which the worker performs the operation, and the amount of natural ventilation present. In some instances where the operations are intermittent and of brief duration, U. S. Bureau of Mines approved respiratory devices have been recommended for protection of the worker instead of exhaust ventilation. Wherever exhaust ventilation has been installed in accordance with the recommendations given in this paper, the atmospheric concentrations have been reduced below the maximum allowable concentrations.

Since such installations are now being made in all loading plants, the number of occupational illnesses and fatalities should decrease. In the not too far distant future, lost time cases from TNT and other toxic materials encountered in government-owned contractor-operated Ordnance establishments may be rare.

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American Industrial Hygiene Association News of Local Sections

Washington-Baltimore Section

TWENTY-TWO members of the A.I.H.A. in Washington and Baltimore met September 19, 1944, to initiate a branch organization. The elected officers are: Chairman, EDWARD B. LANDRY, Chief Safety Engineer, Navy Department; Vice-Chairman, CAPTAIN EDWARD C. RILEY, Army Industrial Hygiene Laboratories; Secretary-Treasurer, RICHARD T. PAGE, Industrial Hygiene Division U. S. Public Health Service. J. J. BLOOMFIELD, A.I.H.A. president, will serve on the Executive Committee, ex-officio, and DR. J. G. TOWNSEND, as an elected member-at-large.

New England Section

AN ALL-DAY program on recent developments was held at Harvard School of Public Health, Boston, December 16, 1944. DR. JOSEPH HAWKINS and DR. HALLOWELL DAVIS, Harvard Medical School, spoke on protection of the ear against noise; DR. HENRY M. O'BRYAN, Baird Associates, Cambridge, on the Pfund gas analyzer; DR. LESLIE SILVERMAN and DR. C. R. WILLIAMS, Harvard School of Public Health and Liberty Mutual, Boston, on an apparatus for sampling large air volumes; LT. F. J. VILES, JR. H-(S) USNR, Boston Navy Yard, and DR. LESLIE SILVERMAN, on operating characteristics of a new welding fume exhauster; DR. C. R. WILLIAMS and MARJORIE LEGGETT, Liberty Mutual, on atmospheric and urinary fluorides from casting of magnesium; LEO LEVINE, Massachusetts Division of Occupational Hygiene, on polarographic determination of toxic metal fumes in air; DR. T. DUCKETT JONES, Harvard Medical School, on recent progress in sterilization of air; SURGEON C. M. MCGILL, USPHS, LT. E. D. STORLAZZI, H-(S), USNR, and PROF. PHILIP DRINKER, on industrial health survey of U. S. Maritime Commission contract shipyards; and ARTHUR C. STERN, R. T. CROWLEY and CHARLES B. FORD, Division of Industrial Hygiene, New York Department of Labor, on a study of perchlorethylene degreasers.

Metropolitan New York Section

AT THE first fall meeting, October 19, 1944, the present status of labeling of hazardous materials was discussed with other timely subjects. DR. MORRIS B. JACOBS, senior chemist, New York City Department of Health, presented a paper at the December 18, 1944, meeting on detection of poisons in foods as related to an industrial hygiene program.

Michigan Industrial Hygiene Section

THE Michigan Society was addressed by DR. E. A. IRWIN, medical director, Cadillac Motor Company, on physical examinations in job placements, and by WM. BARCLAY, Graham Paige Motor Car Company, on proper selection of employees for available jobs, at the October 25, 1944, meeting in Detroit.

Chicago Section

ON October 26, 1944, the Chicago Section was addressed by JOHN KANE, ventilation engineer, American Air Filter Company, on industrial ventilation. Current industrial hygiene literature was discussed by DR. L. E. HAMLIN, medical director, American Brake Shoe & Foundy Company, and the engineering phases of the literature by KENNETH MORSE, industrial hygiene engineer, Illinois Division of Industrial Hygiene. On November 24, 1944, DR. VERNE HERVEY, medical director, Civil Service Commission, and CLARK BRIDGES, Zurich Insurance Company, spoke on certain practical aspects of rehabilitation.

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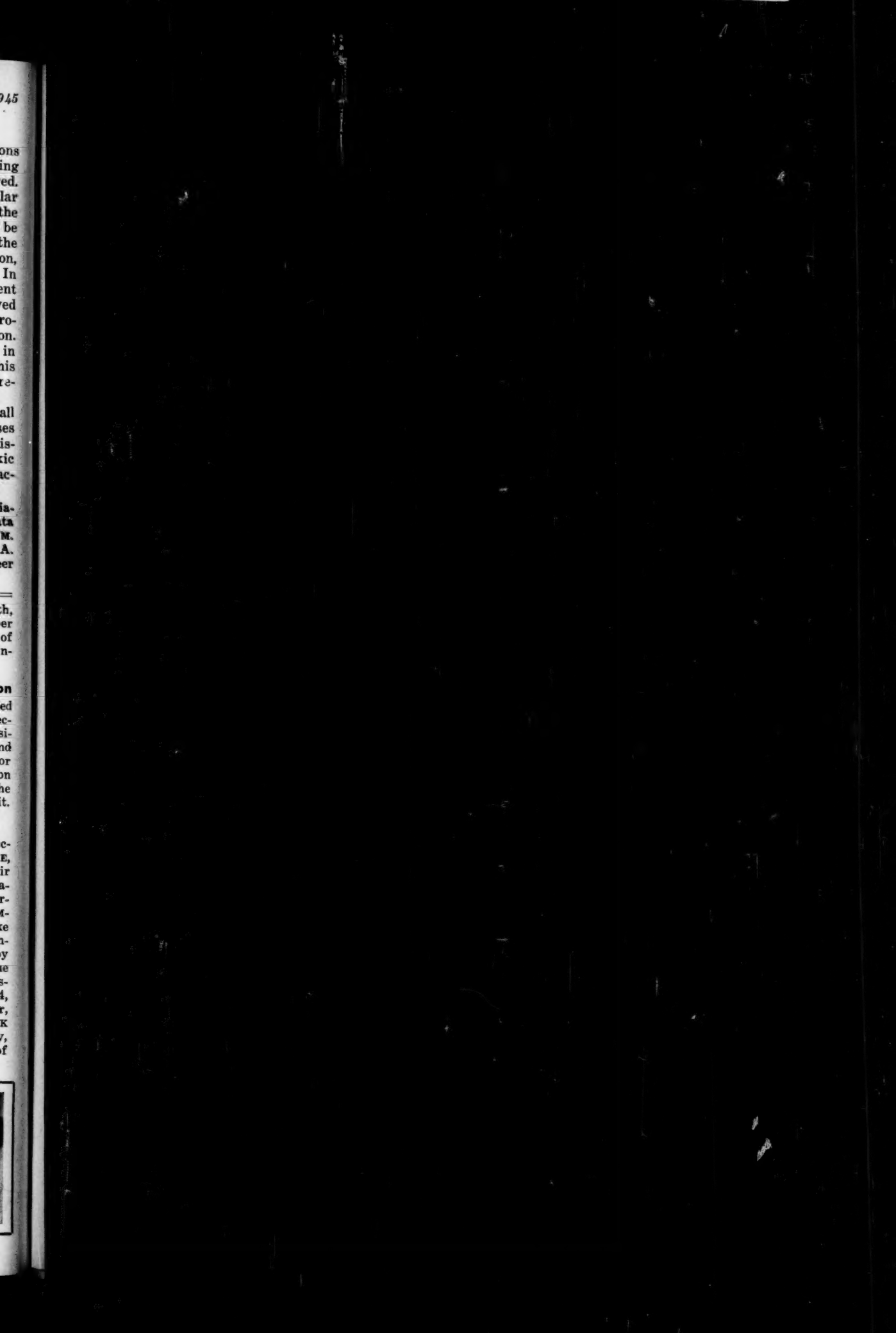
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